LIVING NAMES

SEVEN INVENTORS

By
HARRY McNICOL

ARKWRIGHT
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GOODYEAR
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MARCONI

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RICHARD ARKWRIGHT

I

On a bright spring afternoon in the year 1767 a thick-set man of about thirty-five rode into the village of Heywood in Lancashire. On his rather coarse face was a serious expression as he looked towards the cottage doors, where women and girls sat working at their spinning wheels. Through the open doors and windows came the noise of looms as the weavers sent their shuttles backwards and forwards, weaving together cotton and linen thread into 'fustian'. In those days it was still impossible to make pure cotton cloth from English thread, as the spinning wheel could not make yarn strong enough to stand the strain of the clumsy looms.

The traveller brought his horse to a stand by a small cottage, at the door of which sat a young girl. She was bare-headed, and her rich, chestnut hair hung in two heavy braids over her shoulders.

'I'll give you a shilling for your hair, my girl,' the horseman called to her in broad, Lancashire speech.

The girl stopped her wheel and, blushing, was about to run into the cottage when an older woman appeared at the door.

'What is it, Sarah Jane?' she inquired, looking at the man suspiciously.

'Arkwright's my name, ma'am; the barber of Bolton. I pay a good price for hair to make into wigs. I'll give the lass a shilling for hers and take it off so neatly that she won't know the difference.'

'Come in,' the woman invited, and the barber climbed down from his fat mare and followed her into the cottage.

The living-room was half filled with a loom, at which sat the girl's father. He turned as the newcomer entered: 'Why, it's Master Arkwright! Sit down, lad. I'm very pleased to see you! It's the barber from Bolton I was telling you about, Mary,' he added, turning to his wife.

'How do, Jack!' Arkwright responded heartily, seating himself on the corner of the table. 'How's trade these days? Are you busy?'

'If it isn't one thing it's the other. There was a time when we weavers had to work ourselves to the bone to make enough to keep alive. Now the traveller from Manchester can't give us enough yarn to keep the looms going for a whole week at a time.

'But the loom works faster these days, and you ought to be making twice as many yards of cloth,' put in the barber.

'Yes, but we're paid less for what we do. A couple of years ago Mr Acroyd, my employer, came with his traveller and told me to fix a

fly-shuttle to the old loom. He said I'd weave twice as fast. But he paid me only half the price I'd been getting for each piece. The work's not so hard now; but the spinners can't keep up with us weavers.'

'You want to invent a spinning frame that would work about a dozen spindles.'

'And what would my old woman and the lass do for a living—and all the other lasses as well? Yarn would be so cheap that the travellers would only take the cotton wool to the spinners who had the new frames.'

'They say a man in Blackburn, a fellow called Hargreaves, has made a spinning frame to work eight spindles.'

'Yes! And what's happened to him?' the weaver demanded angrily. 'The weavers and spinners smashed his devil's machine and burnt his house for him. We want no inventors in this part of the country. Why don't they leave honest men to earn an honest living?'

As Arkwright rode along the road to Bolton, his thoughts were far from the bundles of hair in his saddle bags and the wigs they would make. Yes, there was a fortune for the man who could make a spinning frame. Since the joiner of Bury had speeded up weaving by inventing the fly-shuttle, it took four spinners working at wheels to keep pace with one weaver.

For five years he had travelled the roads in search of hair, and it was always the same story: weavers

were idle for want of yarn. And Hargreaves of Blackburn had invented a spinning frame! His own thoughts had been running on such an invention for many months. Had he missed his opportunity, he wondered?

In those days most of the cotton used in England came from countries at the eastern end of the Mediterranean Sea, where the fluffy, white tops of the cotton plants were picked and made into large bundles. Since the cotton wool was very tangled, the craftsmen in England had first to straighten it out. This was called carding, and was done by laying the cotton wool on what looked like a large hair-brush with steel bristles, which was fastened by its back to the table. Then another 'hair-brush' was drawn across this so that the steel teeth combed out the cotton wool.

The next thing to do was to make the cotton wool into a continuous rope. This was called roving. Then came the spinning. You will be able to understand how this was done if you find a piece of string and take out your fountain pen. Tie a loop at one end of the piece of string and catch this under the clip of your pen. Now hold the pen in front of you in your right hand and the string in your left, so that pen and string are in a straight line. Roll the pen round between your fingers, and you will find that it twists the string.

After doing this for some time, move your left hand so that the string is at right angles to the pen,

which you are still rolling between your fingers. The pen will now wind the twisted string round itself.

Spinning is just like that. The pen is the spindle and the string is the yarn, or thread. The spinning wheel consists of a large wheel mounted on a stand, with a belt running round it to the wooden spindle. The spindle is a piece of wood about the same size and shape as a pen. It has a hook on it like a pen clip. The spinner fastens the end of the roving, or cotton wool rope, to this hook. Then she turns the large wheel with her right hand, causing the spindle to revolve very quickly. At the same time she draws out the cotton rope with her left hand until it is very thin. When the spindle has twisted this sufficiently, the spinner moves her hand round, so that the thread is wound up round the spindle. This is done again and again.

There were two drawbacks : the thread so made was weak and thin; and it took four spinners to keep up with one weaver, when the thread was made into cloth on the loom. The loom was a large frame with hundreds of threads running side by side. When the weaver pressed a pedal down, the even threads rose up and the odd ones sank down, and he passed a shuttle between them. This shuttle was shaped like a torpedo, and inside it was a bobbin of thread, which was paid out through a hole in the side of the shuttle. Then the weaver pressed another pedal. Up rose the odd threads and down went the even ones, and back went the

shuttle. It was as if the shuttle were a needle and thread, darning a hole in a sock.

In those days the odd and even threads (the 'warp') had to be made of linen, as the cotton yarn spun by the spinning wheels was not strong enough to take the strain.

Everyone wanted cotton cloth, and since there was not enough thread to make it all, Master Arkwright was quite right in thinking that a fortune awaited the man who could invent a spinning machine to produce strong thread quickly.

II

Darkness came early of an evening in the barber's shop at the end of the lane leading to the 'White Bear' public-house, for the bow window was piled high with lotions, ointments, and cures for the fever and the gout, not to mention two carved wooden heads adorned with wigs.

The barber sat by the fire, his stockinged feet on the fender, his wig hanging from a nail in the mantelpiece. He was studying the back page of the Bolton news sheet with extreme satisfaction.

'Look at this, Meg, lass,' he called to his wife, who was setting the supper table: 'Rich. Arkwright. Wig maker, hair cutter &c in BOLTON, Lancashire. In the newest and best fashion. Makes all sorts of wigs and ladies' locks at reasonable

prices. N.B. The real Duffy's Elixir, Godfry's Health Bottle &c.'

'You know very well I can't read, Arkwright,' the good lady snapped. 'Why you waste a good ten shillings on that notice, and half your sleeping hours studying and thinking of wild ideas about spinning machines, I can't see.'

'A man can never get on unless he chances something. I'm going to charge a ha'penny instead of a penny for haircuts, from now. It will put all the barbers in Bolton out of business.'

Mrs Arkwright's retort was cut short by the opening of the street door, and the entry of a man.

'Goo' day, folks. Wanna hair cut,' he mumbled, dropping into the chair. ''S cold work mendin' the parish church clock, so I dropped in at the "White Bear" for some gin.' He smacked his lips.

Arkwright proceeded with his hair-cutting in silence, in no mood to talk with the drunkard, whose conversation wandered on.

After a while: ''S cold work and hard work mendin' clocks. 'S a thankless job, too. But John Kay of Warrington won't mend clocks all his life. Great an' successful spinning master! Me and Mr Highs make machines spin by rollers. 'S great secret!'

'What d'ye say?' Arkwright asked sharply.

Kay winked and shook his finger in the other's face. ''Sh great secret!' And that was all the barber could get out of him.

That night Richard Arkwright sat long, gazing into the dying fire. Spinning by rollers ! So that *was* the solution. His own mind had been working in that direction. His thoughts travelled back a year. He had been in Birmingham and had seen, through the open door of a forge, a white-hot bar of metal squeezed thin between steel rollers. Why could not cotton yarn be stretched and made firm by being passed between rollers, each pair going faster than the pair before ?

III

Richard Arkwright, dressed in his best suit, and carrying his wife's last £50 in his pocket, walked the streets of Warrington in search of the workshop of one John Kay, clockmaker. He found it at last, and pushed open the door to find Kay himself, surrounded by clocks, at work at a lathe.

'What's your pleasure, sir ?' the clockmaker inquired.

'My name is Richard Arkwright, of Bolton.' He spoke stiffly, trying to avoid the use of his broad speech. 'I am interested in spinning machines ; and I am told you have some skill in that direction.' He watched the man carefully; but obviously Kay did not recognize him.

'I . . . I know nothing of spinning, Master Arkwright. Clocks are my trade,' came the uneasy reply.

'That looks uncommonly like the model of a

spinning frame, though.' Arkwright pushed the protesting craftsman aside, and stooped to examine a machine in a corner of the workshop. 'Four pairs of polished, metal rollers, each pair travelling faster than the one before it. And spindles to twist and wind the yarn.' Arkwright paused in thought, while Kay moved from one foot to the other in keen distress.

'Look here, my man.' The barber thrust his face close to that of the frightened clockmaker. 'It will not work. Those smooth rollers will not do the trick. I know the right way.'

'But, sir ——'

'Master Kay,'—Arkwright suppressed his own excitement and spoke calmly —' if you hope to live in comfort in your old age, that machine will not make you the money to do so.'

'But, it isn't my ——'

'Hold your tongue, man! You will turn me some pieces of brass and bend me some wires. These you will bring to Bolton in two days. Here are ten sovereigns to show you that I pay well. You will be a rich man, one day, John Kay.'

The clockmaker hesitatingly took the money.

'Now fetch a pen and paper, and I will draw you what I want.'

IV

In the weeks that followed the Bolton barber cut fewer and fewer heads, and the business of

wig-making came to an end for lack of hair. Tom, his assistant, sought work elsewhere; and Mistress Arkwright was in despair. Her husband seldom came down from the attic, which he had made into a workshop, except either to go to Warrington or to receive John Kay.

Months passed and the autumn came. One evening Arkwright came to the kitchen, where his wife sat darning.

'Meg, my dear, I've done the trick at last. Come and see.' And he ran up the stairs, his face beaming. She followed him, her hands clenched with anger.

'There it is, lass; and it works perfectly.' He indicated the model of wood and brass that stood in the middle of the floor.

'And into that useless toy has gone all our savings. You've lost your business, and you've spent every penny of mine. We're in debt, and we're going hungry. Dick Arkwright, you are mad, and worse!' Her voice rose in anger.

'I tell you, our fortune is made. I'll spin more ——'

'Fortune made! Why I married a fool like you, I don't know. This for your child's toy that has made us beggars!' She picked up a heavy hammer and dealt blow after blow at the machine.

For a moment Arkwright stood speechless. Then, with a roar he seized the angry woman and hurled her against the wall.

'Would you raise your hand to me?' she screamed. 'I'm finished with you. I'm going home to my father!' and she ran out of the room.

Arkwright, stunned, sat down on a stool, gazing at the wreckage of splintered wood and twisted metal. Only after he had heard the street door slam did he move. Then: 'I suppose I can't blame her. She doesn't understand. It took months to make. But I know it works, and I can always make another.'

V

A few days later Arkwright left Bolton, the money he had got from the sale of his shop and house in his pocket. He tramped to Warrington, and, accompanied by Kay, called on a Mr Atherton, an iron master, who had the workmen and the forges necessary to make a full size model of the spinning machine. But Atherton could not be expected to lay out money for what seemed a hare-brained scheme, in the hope that this ill-dressed, broad-spoken man would repay it. He turned Arkwright and his mechanic away; but, impressed by the former's terrific enthusiasm and self-confidence, promised to lend him two workmen, who would carry out the heavier part of the work.

At last, after months of labour, when neither Arkwright nor Kay had enough to eat, the spinning frame was complete. The next difficulty was to

find someone with money, who would have sufficient confidence in the invention to build a factory and set it working, for the machine could not be turned by hand.

Then Arkwright thought of Mr Smalley of Preston, whom he had known many years before. Making his rags look as neat as possible, the inventor arranged to meet this gentleman.

'I see from your letter that you have a new spinning machine,' Smalley said, as they sat in his house.

'Yes, sir. And it will produce yarn—strong yarn, that can be used instead of the linen—faster than a hundred, even a thousand, spinning wheels.'

'You say it spins by rollers? But that was tried thirty years ago, and nothing came of it.'

'Aye! but they were smooth rollers!' Arkwright exclaimed. 'My frame has four pairs of rollers, the top ones covered with leather, and the bottom ones grooved. The cotton passes between them, and, since each pair revolves faster than the pair before it, the cotton is stretched evenly, and is then twisted and wound on spindles.'

They talked far into the night, and at last Smalley consented to see the machine. It was to be assembled in the parlour of the Grammar School master, who was a friend of Smalley, his house being well screened from prying eyes by trees and bushes.

VI

'There are strange doings in the school house next door, Mistress Thomson,' said the cobbler, as he handed in the boots he had repaired.

'Yes, my good man! All the neighbours are gossiping about it. My sister and I hear terrible, fearsome noises at night. We went to tell Mr Smalley the magistrate. My sister is sure it is Satan tuning his bagpipes. John Henry, the gardener's boy, peeped in through the window-curtains and saw those two ragged men, who are lodging at the butcher's, dancing a devil's horn-pipe.'

'And what did Mr Smalley say, ma'am?'

'He laughed, and told me that the Devil would not bother us, for we go to Chapel twice every Sunday,' the old lady replied indignantly.

Inside the school house, unaware of the local excitement they were causing, Arkwright and Kay were at work on the machine. Mr Smalley entered, carrying a bundle.

'Well, Dick, I've brought you your suit,' he laughed, throwing the bundle on the table.

'What suit?' Arkwright asked, puzzled.

'You said you wouldn't turn out to vote for me at the election unless you had a new suit to wear.'

'Have you come to a decision yet, Mr Smalley?'

'Yes, my lad! What I saw of the machine last night decided me. I have paper and pens here, and

we shall draw up the details of the frame and apply for a patent. As soon as that is granted, we shall go into partnership.'

The next year they set up a factory in Nottingham, where the new spinning machine was driven by wheels turned by horses. Miles of cotton, strong even cotton, came from the spinning frames. The manufacturers refused to buy it, so the ambitious Arkwright got in touch with some rich stocking makers, Messrs Need and Strutt, who, when they saw his yarn, offered to take all he could turn out. They made him their partner.

So Richard Arkwright, deciding that horses were not sufficient to drive his machines, with the assistance of Need and Strutt built a great mill in a valley near the River Derwent, driven by water from a warm spring that never froze in winter. And so Arkwright's machine became known as the 'Water Frame.'

For over twenty years these three worked in partnership, first of all making stockings, and then, in 1774, cloth, entirely of cotton, the first that was ever manufactured in England. In the following year Arkwright made two more inventions; one for carding—that, you will remember, is straightening out the fibres of cotton wool; the other for roving—that is making the carded cotton into a long rope, ready to be paid into the spinning machine. These he built into the Water Frame, so that cotton wool could be fed in at one end and spun yarn would come out at the other, all the

complicated processes being carried out entirely by the beautifully adjusted machinery.

He built several other mills, with spinning sheds where Water Frames hummed, and weaving sheds where hand-loom weavers jerked their shuttles back and forth. One of the new factories was burnt to the ground by cottage spinners and weavers, who considered that the great manufacturer was taking their crafts away from them. But Arkwright persevered, unyielding in business; always insisting that his workers should do good work, and treating them well in return. His factories were, in fact, the cleanest and best organized in England.

Other manufacturers were permitted to use the Water Frame, if they paid Arkwright for allowing them to do so. But they were not satisfied with this, and many of them built spinning frames that were only slightly different, and claimed that they were quite different machines. Others bribed Arkwright's mechanics to tell them the secrets of the machine. They then built Water Frames and used them behind locked doors.

VIII

In the year 1781, in answer to an advertisement in the *Manchester Mercury*, a large number of cotton masters met at a Manchester inn.

'Gentlemen,' said Mr Armstrong, one of the

wealthiest and most powerful, 'we are all suffering considerable loss on account of that upstart barber from Bolton. I mean Mr Richard Arkwright. He is selfishly keeping for his own use a spinning machine, which, in the interest of England and of all of us, everyone should be allowed to use.'

There was a buzz of agreement from the company.

'But, sir, Arkwright has a patent. And that lasts for some years. So he has the law on his side,' someone put in.

'After a great deal of trouble I have been able to prove beyond doubt that he did not invent the roller spinning machine,' went on the first speaker. When the astonished exclamations and the hum of excitement had died down, he continued: 'In fact, I have witnesses here to prove what I say. Bring in Mr Highs and Kay,' he called to someone at the door.

Our old friend, Kay, twisting his hat nervously in his hands, entered, accompanied by another man.

'Now, Kay: you know Mr Arkwright?' Mr Armstrong questioned.

'Know him? I should say I do, curse him! Didn't I tell lies for him and work myself to the bone, because of the promises he made me? And then he turned me out, telling me I had robbed him!'

'And you, Mr Highs?'

'It was I who invented the roller method of

spinning. Arkwright bribed Kay, who was my mechanic. He forced his way into Kay's workshop and examined my model, which I had foolishly built there.'

And so the plot was hatched. The case was tried the following year, and it was decided by the judge against Richard Arkwright. And so it was that this marvellous invention, the first that did work more surely and skilfully than the cleverest hands, was thrown open for the use of all.

But the loss of his patent did not injure Sir Richard (for he was made a knight in the year of the trial and High Sheriff of Derbyshire the year after), and he built more mills and became even richer than before.

When he died, in 1792, before his great mansion, Willersley Castle, was completed, he left half a million pounds, which was then worth far more than it is now.

And what did Arkwright do for England? Before his death his machines, or 'throstles' as they were called, were driven by steam engines. They turned out millions of yards of cotton yarn, which could be made into cheap, easily-washed clothing. He showed the world how machines could do the work of many men. He made it necessary to gather the workers into factories.

His life is a lesson in perseverance, and in courage to overcome difficulties. When he was fifty years of age he used to spend one hour a day studying

spelling, and another improving his grammar. But we cannot admire his hardness, his ruthlessness.

He was, in fact, one of the men who did most to make Great Britain the workshop of the world; and if we seek a name to describe him, we can call him 'the Father of the Factory'.

JOSIAH WEDGWOOD

I

'JOSIAH, come here!' called the burly man from the door of the workshop.

The boy at the bench apparently did not hear, in spite of the loudness of the call. He dipped his brush in the pot of enamel and, with the greatest care, proceeded to apply the colour to the article he was decorating.

'Confound the boy!' muttered the man who had called. Folding his arms he strode across the room. With a frown he stood for a moment looking down at the young craftsman, who was so intent on his task that he had not noticed the approach of the other.

'Josiah!' the man bellowed, almost in his ear.

The startled boy jumped, and his brush smeared the blue enamel in a streak across the design he was painting. He turned, clenching his fists with rage, then, seeing who had disturbed him, checked himself.

'Why did you do that? You've ruined it,' he cried hotly.

'Didn't you hear me call you? Must I come running to find my apprentices every time I want them?'

'But ——'

'Be quiet! You seem to think that, because you are my young brother, you can take what liberties you like. But remember this, Master Josiah Wedgwood; you are my apprentice, and I am your master. You are not a master potter yet, and never will be, if you waste your time like this. What have you been playing with, anyway?' He picked up the tiny piece of earthenware from the bench. 'A snuff box, eh!'

In spite of his annoyance, Master Thomas Wedgwood had to admit to himself the beauty of the dainty little box, with its sprays of flowers in blue and green. He was a skilful potter himself and he realized that his youngest brother was much cleverer at this kind of work than many men.

'I can't keep the business going if my workmen spend their time making these toys,' he said more quietly. 'I've let you do decorating work because your leg hurts you when you work at the wheel; but I expect you to do as you are told.'

'But I've ——'

'Don't answer me! Go and help Jack to put those saggers in the kiln.'

With a sigh Josiah Wedgwood limped out of the workshop.

II

Young Josiah Wedgwood was learning to be a potter, like all the rest of his family, and his father

and grandfather before him. In fact for over a hundred years before 1730, when he was born, the Wedgwood family had earned their living by making pots in Staffordshire.

Let us see how pottery is made. Everyone uses the terms 'china', 'earthenware', 'porcelain' and 'pot'; but it is not everyone who knows the difference in their meanings. The word 'pot', means any of them; it is like a Latin word for drinking-cup. There are two kinds of pot—earthenware, and porcelain (or china, as it is sometimes called, for the white clay from which it is made was found first in China). Porcelain, then, is a special kind of pottery made from the white china-clay, or kaolin. Earthenware, on the other hand, is made from commoner clays.

It is quite easy to tell one from the other, for, if you hold porcelain to the light, you can see the light shining through it. Only very thin and fine earthenware would let light pass, and then only a little.

No one knows who was the first person to make articles of clay. Clay pots many thousands of years old have been dug up. Before that time it was only possible to carry liquids in sea-shells, gourds and skins. Then perhaps some observant person noticed that, after a rainfall, a footprint in clay soil held water. He then realized that clay could be very useful, and decided to try coating the inside of a basket with it. Imagine his delight to find that the basket would now carry liquid!

But one day this experimenter was careless, and left the basket too near his fire. It caught fire. By the time he noticed what had happened, all the basket work had been burnt away, and the clay lining had baked hard. That, perhaps, is how the first clay vessel was made, and how the first hot drink became possible !

We see, then, that to make clay vessels it is necessary first of all to shape them, and then to burn them in order to make the clay hard. How was this done when Josiah Wedgwood was learning to be a potter ? Almost exactly as it is done to-day.

The county of Staffordshire contains many different kinds of clay, so that it has become famous as a pot-making district. The clay was first dug out of the ground and then left to stand in heaps for a long time. Then it was ground up with water between mill stones, the different kinds of clay being mixed together, according to the potter's recipe for the kind of earthenware he was making.

The clay and water mixture, which is called ' slip ', came out of the mill looking like cream, and it was put through fine sieves to remove any particles of earth or stone. For a long while the thick, creamy liquid was left to stand in an open tank, so that the water would evaporate from it. When it had become thick enough to be worked like plasticine in the hands, lumps of it were cut out of the tank and the potter took them to his wheel.

The potter's wheel is a very old machine indeed, for we read of it in the Bible. It is a low, wooden stand, with a round plate on top, which revolves like a gramophone turn-table. The potter works it from underneath with his left foot.

The potter now takes a ball of clay large enough for the pot he intends to shape, and throws it on to the wheel, so that it sticks firmly. Then, placing his hands on each side of the clay, and turning the wheel with his foot, he cleverly shapes his material as he wants. Then he pushes his thumbs into the round clay at the top and works it hollow. Before long, as if by magic, the skilful potter has fashioned the uninteresting lump of clay into a beautifully shaped cup, or bowl, or jug.

Making pottery on the potter's wheel is called 'throwing', and a thrower is a very skilful workman. But there is another method of shaping articles out of clay—'moulding'. A plaster mould is made and the clay is pressed into it. This is a quicker and less difficult way, and it must be used to make things like handles; but all the most beautiful pottery is thrown.

When the piece of pottery is taken off the wheel, it is put aside to dry, after which designs may be painted on it with special colours that will stand great heat; it is then ready to be fired. This is done in a large oven, or 'kiln'. The pieces of pottery are placed in earthenware tubs called 'saggers', so that the flames cannot touch the pottery. When these saggers have been piled on

top of one another until the kiln will hold no more, the doorway is bricked up and a large fire lit through a hole in the base of the kiln.

For three days the furnace is kept burning, and then the kiln is left for another three days to cool; but sometimes, when a special piece of work is being done, the firing takes a whole month, and cooling half a month! You can imagine the potter's anxiety when he opens the kiln, in case anything may have happened to the pieces of pottery over which he has taken so much trouble.

When the pottery comes out of the kiln, it is called 'biscuit' and it feels rather like an ordinary red flower-pot. It cannot be used yet, for, unless it is a very hard earthenware, called stoneware—ginger-beer bottles are often made of this—it will allow liquids to soak through it. The next step, then, is 'glazing', or covering the pot with a very thin coating of glass; but before this is done, the biscuit is decorated, if this has not been done already. This is called 'under-glaze decoration'.

After the pot has been dipped in the liquid glaze, and this has dried, it is placed in the 'glost kiln', where it is again fired, so that the glaze is burnt into it. When it comes out, the pot is ready for use, unless the potter decides to paint it with enamel over the glaze. If so, the article is fired a third time in the 'enamel kiln'. Thus a great deal of work goes to the making of the cups and saucers we use.

III

When Josiah Wedgwood was a boy, only earthenware was made in the Staffordshire potteries; but much had been done to make this look attractive. Most of the pots were made of a very hard type of earthenware called 'stoneware', which we have already mentioned. This was glazed with salt; and there is a rather interesting story of how this method of glazing was discovered in England.

In the year 1680 the servant of a certain Mr Yale was boiling some salt and water in an unglazed earthenware pot, for she was going to pickle some pork. The pot tipped over, and the salty water was spilt into the fire. When the pot, which had become red hot, was rescued, it was found to be covered with a fine, smooth glaze. Mr Yale, on hearing about it, saw that here was an improvement, and soon the potters learnt from him how to shovel salt into their hot kilns, so that the fumes would glaze their pots.

There is another interesting story of how a famous potter called Astbury learnt to mix powdered flint in his clay to make his pot whiter. He was travelling to London in 1720, when he discovered that his horse had a sore eye. Stopping for dinner at an inn, he asked the ostler if he could do anything to cure it. The man found a piece of flint, which he heated in the fire until it was red hot, and then threw it into a bucket of water. The flint at once fell to pieces and the ostler was able quite easily to

crush the hard stone into a fine powder, and this he blew into the horse's eye. Astbury was so struck by the whiteness of the flint powder and this easy way of crushing it, that, when he returned to his pottery, he began to mix powdered flint with the clay he was using.

Soon other potters began to use flint also, and then a dreadful thing happened: it was found that the fine flint powder got into the lungs of the men who crushed it, and gave them the terrible disease known as 'potter's rot'. Many workmen died of this before a safe method of crushing flint was discovered.

We have seen, then, that a great many improvements were being made in potting, when Josiah Wedgwood was serving his apprenticeship. Let us see what he did to make English pots the best in the world.

IV

Josiah was born in 1730, and was the youngest of thirteen children. Seeing that almost everyone in the town of Burslem, where his parents lived, were potters, and in the four other little towns of Tunstall, Hanley, Stoke, and Longton nearby, there is little wonder that Josiah was interested in pottery. He went to school until he was eight, and then his father died, so he had to leave; but he still continued to study, for he had decided to become a famous potter.

When he was eleven, he became very ill with smallpox, and ever afterwards one of his legs troubled him. This must have been a great disappointment, for it prevented him from working much at the wheel. Instead he took an interest in designing and decorating, and he began to study chemistry, so that he would know how to carry out experiments to discover new kinds of glaze and different mixtures of clays.

When he was fifteen he became apprentice to his eldest brother, Thomas, and, during the next five years, he learnt a great deal about pottery. But we have seen at the beginning of this story that his brother had not a great deal of patience with his experiments and, when the five years were over, Josiah decided to go into business with another potter. But he was not satisfied, for this man was even less eager for his new ideas than his brother had been, so he decided to work with the great potter, Thomas Whielden.

One day when Whielden was looking through his account books in his office, Wedgwood, now a man of about twenty-five, entered and placed a small pile of plain white plates on the desk in front of the older man.

'There you are, Mr Whielden. We've just opened the small kiln. What do you think of them?'

The master potter picked up one of the plates and examined it carefully. 'They are far better than any we have made before,' he admitted at last, 'but what are they like under the glaze?'

Wedgwood picked one up, and broke it against the edge of the table. He handed one of the parts to his partner, so that he could examine the pale cream-coloured clay inside.

Whielden nodded approvingly. 'If we can turn out pots like that, no one will buy the ordinary stoneware.'

'It isn't the stoneware that is worrying me,' the young man said seriously. 'I've heard it said recently that china clay has been discovered in Cornwall. If they start to make real porcelain, like that brought from China, what will happen to the Staffordshire potteries? No one will buy our pots and the whole district will be ruined.'

'What's your idea, then?'

'Now that everyone is drinking tea and coffee, more and more cups and saucers and teapots will be needed: and you know as well as I do that the salt-glazed ware we make here won't stand the hot tea. Before long, if we don't do something to stop it, people will only buy porcelain.'

'And you think that if we can improve this cream-coloured ware of yours, people will buy it instead of china?'

'Yes. And we can improve it, if we continue to experiment—and produce it at half the price of china, too.'

For the next few years Wedgwood continued to improve his cream-coloured ware. In 1758 he left Whielden and set up in business as a master potter, renting the Ivy House Works in Burslem.

V

Soon people began to talk of the new master of the Ivy House Works, telling how he gave each workman one job, and one job only, to do, so that he became very clever in carrying it out. Inside the works there was none of the dirt and untidiness of the other potteries. New tools were invented, and anyone who bought a Wedgwood teapot or jug could be sure that it would pour properly and that the lid would fit.

Wedgwood continued to improve his cream ware and in 1762 he was so pleased with his results that he presented a beautifully painted breakfast service to Queen Charlotte. The King and she were so delighted with it that they ordered other services and allowed Wedgwood to call himself 'Queen's Potter'. From this time the new cream-coloured pottery was always called 'Queen's Ware'.

Wedgwood was now known all over England and his beautiful and cheap 'Queen's Ware' was being sold everywhere. He now began to build a large factory and near it a village, where the work-people could live, and this he called 'Etruria'. Etruria was the ancient name for a part of Italy where, in Wedgwood's day, antiquarians were digging up beautiful vases and other works of art. The buried city of Pompeii was also being uncovered. Wedgwood was much interested in all beautiful things, and the ancient treasures of Italy particularly attracted him.

Wedgwood had been working for many years to invent a special kind of stoneware, which he called 'jasper', and this is, perhaps, the most beautiful pottery in the world. From this he made blue, green, violet, pink, yellow, and black models of Etruscan vases, which were very beautiful and soon became very popular. So great was the demand for his pottery that Wedgwood opened showrooms in London. Here are some of the things which were mentioned in his catalogue: heads of famous people, copies of medals, models of animals, tea and coffee services, teapots, vases, flower-pots, candlesticks, snuff-boxes, inkstands, thermometers, and dozens of other things. All the rich people, and even the King and Queen, came to buy; and so well known were his wares all over Europe, that his catalogues were printed in several languages.

Perhaps Josiah Wedgwood's proudest moment was when he was told that the Empress Catherine of Russia wished him to make her a great dinner service of 'Queen's Ware'. He decided to make the most wonderful set of china in the world. It was large enough to allow fifty people to sit down to dinner: there were 952 pieces and on them were 1,282 different views of England painted by the cleverest artists of the day. The colour was pale yellow, with the views painted in purple, while round the edges of the plates and dishes were oak leaves. On a little shield on each piece was painted a frog, for the Empress's palace was called La Grenouillière, which means 'a marshy place full of

frogs'. This magnificent service cost £3,000 and delighted Catherine very much.

VI

Earthenware had now improved so much that the potters no longer found the clays of Staffordshire good enough for their purpose, and finer clays were brought from the south of England. Since trains were not yet invented and the roads were too bad to allow carts to travel far, these clays were brought by sea as far as Chester and then carried to the Potteries on the backs of horses. This was, of course, very slow and expensive.

But Wedgwood heard that a nobleman called the Duke of Bridgewater had employed a clever engineer, James Brindley, to build him a canal from his coal mines at Worsley to Manchester. This canal had been so successful that the Duke was thinking of building another one right across England to join the rivers Mersey and Trent. When Wedgwood heard of this, he went to see the Duke and persuaded him to make the canal pass through the Staffordshire Potteries. And so the clay could be brought cheaply and the pots could be sent away to be sold. Wedgwood also did a great deal to improve the roads round the Potteries.

For the greater part of his life Wedgwood's leg troubled him till at last he decided to have it cut off. But although he was lame, he was never idle.

When he was not reading or experimenting, he was stumping round his factory, and if he found a workman making a piece of pottery which was not perfect, he would throw it to the ground and cry: 'This won't do for Josiah Wedgwood!' The workmen never objected, for they knew that he himself was a better workman than any of them.

In 1795 the great Josiah died, leaving over half a million pounds, besides his factories, which are working busily to this day.

And why do we consider him one of the greatest Englishmen? He gave people cheap, useful, and beautiful china, which was sold all over the world. He changed the Staffordshire Potteries from a group of small, untidy towns into one of the busiest and richest parts of the country. And he made many very beautiful things, which will always help to make people happier.

CHARLES GOODYEAR

ONE day in the year 1834 a thin, shabbily dressed little man walked along a street in New York, glancing into the shop windows, but seeming to take little notice of what was going on around him. Then he stopped and, retracing his steps a few yards, gazed into one of the shops. Among a large number of different articles for sale he saw what was advertised as an 'Indian-rubber Life Preserver: Made from strong cloth coated with Indian-rubber, which renders it waterproof. Being inflated with the Breath, it will prevent the Heaviest Man from Drowning. Price, $1·50.'

After a few moments' hesitation, he entered the shop, placed one dollar and fifty cents on the counter, and came out with the life-jacket under his arm.

The next day, after completing his business in New York, he returned to Pennsylvania to his family.

'What luck have you had, Charles?' his wife inquired, as they sat down with the children to the evening meal.

'Little enough, my dear Clarissa. People don't seem to have heard of Charles Goodyear, the inventor.'

'But you have invented many useful things: things that everyone needs.'

'Yes. I have invented new buttons, new spoons, and new hay-forks; but people seem to think that, as the old type of buttons will fasten their clothes, and the old spoons will stir their tea, and the old forks fork their hay, why need they bother about new ones?'

'But you have had them all patented.'

'And where does all the money go? It costs a deal to get a patent; and once I have got it, I have never enough money to start making the buttons and spoons and forks. So I have to sell the inventions to others and pay my debts with what I get from them. And even then they put me in prison for being in debt.'

'Never mind, my dear!' Mrs Goodyear replied soothingly, 'it is God's will that His people shall be tried with these troubles.'

'What's in the parcel, Father?' nine-year-old Ellen asked, pointing to the brown paper bundle her father had placed on the sofa.

'Bring it here, and I'll show you.' The child brought it and Goodyear unwrapped the life-preserver.

'What is it?' the little girl and her mother asked together.

'It's a life-jacket; and instead of being filled with cork it has to be blown up.' Goodyear fastened it round his chest and inflated it.

'But what is it made of? Ugh! it has a horrid smell!' the little girl exclaimed.

'It's made of gum-elastic, or Indian-rubber, as some people call it.'

'But why did you buy ——'

'My dear, I know I should not have bought it, for I have scarcely any money left: and I cannot say why I did buy it. I have always been interested in this gum-elastic. It could be used to make all sorts of things.' He fingered the rather sticky, ill-smelling material of the life-preserver and became lost in thought.

At last he looked at his watch. 'Eight o'clock. It's time for bed, children. Hand me the Bible, Ellen, and I'll read Prayers.'

A few weeks later Charles Goodyear was again in New York on business. He sought out the shop where he had bought the life-jacket, and asked for the manager.

'I've made an improvement in the tube for inflating this life-preserver of yours,' he told him, unwrapping the article, which he had brought with him. 'I thought you might perhaps buy the idea from me.'

'My dear sir,' the business man answered him, 'I am truly sorry; but I cannot spend any more money on these rubber articles.'

Goodyear could not hide his disappointment and the manager felt sorry for him. Leaning over the counter, he said in a low voice: 'The fact is, that it is almost impossible to make any money from Indian-rubber, for half the articles we sell are returned to us because they have not given

satisfaction. In hot weather they grow sticky and smell: in winter they grow hard and brittle. I am telling you this, because I want you to know that I would help you if I could. But it isn't new ideas for blowing up life-preservers that we want: it is a method for keeping Indian-rubber soft in winter and dry in summer.'

'But don't you think that rubber has a great future?'

'The man who can treat rubber as I have said, will make a fortune. I am sure of that.'

As Goodyear travelled home, he made a great decision. He would devote his life to making rubber into an article that would be used by all. And what uses it would have! Not only for life-preservers, but for clothes, tents, boats, shoes—hundreds and hundreds of uses. Yes, that was the sort of invention to devote himself to. That was the sort of discovery that would really benefit mankind, which would make men take notice, when buttons and spoons and hay-forks would not. By the time Charles Goodyear reached home, he felt that God had spoken to him and given him his task.

II

People had known about rubber for hundreds of years. Christopher Columbus, who had discovered America, told how he had seen natives playing with balls made from the sap of a tree, and

Cortez, another discoverer, had watched a game played by the nobles of King Montezuma of Mexico, with bouncing balls.

Two French scientists, who travelled in South America, wrote about it in the middle of the eighteenth century, and it was then called 'caoutchouc'. It was in 1770 that the English scientist, Dr Joseph Priestley, wrote in one of his books: 'I have seen a substance excellently adapted to the purpose of wiping from paper the marks of a black-lead pencil. It must, therefore, be of great use to those practising drawing.' He goes on to say that it was to be had of a certain Mr Nairne opposite the Royal Exchange in London at the price of 3s. for a half inch cube. And that is how rubber got its name—because it was first used for rubbing out pencil marks. It was called 'India' rubber because it came first from the West Indies.

For hundreds of years the 'Indians' who lived near the great River Amazon in South America, had made the sap of the rubber tree into shields, bottles, and shoes. They used to make a cut in the bark of the tree and coat their feet with the sticky juice, which oozed out. Then, when this coat had dried, they would add another and another on top, until their feet were covered with shoes of rubber. Since the rubber would stretch, these could be taken off quite easily. Bottles were made by coating a clay mould with rubber.

In 1820 a pair of these shoes, decorated with gilt, was brought to Boston in the north-east of the

United States, and soon rubber shoes became the rage. A ship that had touched at Brazil would sail into a North-East Coast harbour. Here the merchants were waiting to take the bundles of shoes to their warehouses, where, assisted by women and boys, they worked all night preparing the shoes for sale the next day.

First the bundles were untied and the grass, which had been stuffed inside them to keep them in shape, was pulled out. Often the women would scream, when a scorpion or some fearsome spider from the jungle came out with it. Then the shoes were heated and stretched over 'lasts', which are pieces of wood shaped like human feet, to make them the correct size. When they had been polished with blacking, and the sizes and prices had been marked on them, they were ready to be sold. The merchants made a fine profit from them.

People soon began to realize how useful this waterproof material could be. It had been discovered that rubber could be dissolved in turpentine, and very soon people were trying to coat leather and cloth with rubber, trying to make waterproof shoes and clothing.

In the town of Roxbury in Massachusetts was a factory owned by John Haskins, where patent leather shoes were made. At this factory worked Edwin Marcus Chaffee, who was interested in India-rubber. He dissolved in turpentine the shoes and bottles that came from South America, and spread the rubber solution on cloth, leaving it a

few days to dry. Then the rubberized cloth was made into wagon covers, life-jackets, waterproof coats, and many other articles, which were sold. But soon the people who had bought them began to return them and demand their money back, for in hot weather the articles became a sticky, smelly mess; and in cold weather they grew brittle and cracked.

Chaffee had been so sure that his waterproof cloth would be successful, that he had started a factory of his own, the Roxbury India Rubber Factory, and later he invented a huge machine, called the 'Monster', for it weighed over thirty tons, which looked like a great mangle with many steam-heated rollers. His idea was that, if the rubber was rolled into the cloth under great pressure, it would not grow sticky or brittle. But, even so, this did not solve the problem. From this great machine is descended the 'calendar', which is still used in the rubber industry.

III

But what of Charles Goodyear? We left him when, after examining a rubber life-jacket—perhaps made by Chaffee—he had decided to devote his life to improving rubber by solving the problem of how to prevent it from growing sticky in warm weather and brittle in cold.

Goodyear was born in 1800 at New Haven, Connecticut. His father, Amasa Goodyear, was

prosperous, for, as well as being a farmer, he had a factory where buttons, farming implements and other hardware articles were made. He had also invented several things. The Goodyears were keen church-goers, and to the end of his life Charles was deeply religious.

When he was seventeen his father apprenticed him to a firm of merchants at Philadelphia, Pennsylvania, and, having learnt the business, he returned home to help his father at the factory.

It was now that the bad luck overtook him which was to follow him all his life, for his health broke down completely. From then until his death he was seldom well. When he was twenty-four he married Clarissa Beecher, who must have been one of the most patient women in the world, for she never complained through all the hardships that they later suffered. Two years after their marriage they moved to Philadelphia and started a hardware shop to sell the things made in his father's factory, and, for a while, they were quite successful. Then trade began to fall off. He was sent to prison for debt and the store had to be closed.

Goodyear, when he came out of prison, became a blacksmith. This work, however, did not pay very well, so in 1831 he decided to become an inventor. In the same year sorrow came to his house, for two of his little daughters died. It was during the next four years that he invented the buttons, spoons and hay-forks of which he and his wife were talking at the beginning of this story.

But those to whom he owed money were always on his track and he made scarcely enough to live.

But Charles Goodyear would never give in. He sold a lot of his furniture, sent his family to live in the country, and moved himself to New York, where, by his charming manner, he persuaded some chemists to help him with his experiments on rubber. This time he was rather more successful, and, by using quicklime, succeeded in making some rubber sheeting. For this he was awarded a silver medal by the Mechanics' Society ; but before long the sheeting began to go sticky and he was no further on after all.

One day, when using nitric acid to clean stains from a piece of rubber he was working with, he found that by using this acid a better rubber sheet could be made. This was his first success. He got a patent and began treating rubber with nitric acid, nearly poisoning himself with the fumes.

He then persuaded people to put money into his discovery. A factory was taken at Staten Island, where the Goodyears now moved. But in that year a wave of bad business spread over America, and his friends had to refuse the help they had promised.

Goodyear was so hard up that he had even to pawn his umbrella, and one of Mrs. Goodyear's silk petticoats was used to make rubber caps.

Goodyear went to see John Haskins of the Roxbury India Rubber Works, where Chaffee had

built his ' Monster ', and permission was given him to work there. To his delight, he received an order to make 150 mail-bags for the Government. But, to his dismay, they went soft and sticky and, to make matters even worse, the Roxbury works had to close down because business was so bad.

But nothing could defeat him. He raised money in some way and bought a small factory, the Eagle Works, at Woburn, from a man called Hayward. At this time both Goodyear and Hayward had come to the conclusion that the use of sulphur—they did not quite know how—might solve the rubber problem. These two worked together at the Eagle Works, and the rubber they made was certainly better than ever before. But soon customers began to bring back articles that were not satisfactory, money had to be returned, and Goodyear found himself again without a penny and imprisoned for debt.

IV

Charles Goodyear and his two brothers, Nelson and Robert, sat round an iron stove in the house of Elizabeth Emerson in Woburn in January 1839.

' If you'll take my advice, Charlie, you'll throw up the whole business,' Nelson was urging.

Robert grunted his agreement.

' You two don't understand how I feel about rubber; no one does,' the inventor declared, rising

and walking up and down. 'I tell you, it is my task in life to make rubber usable; God intends me to finish the job, and finish it I will.'

'That may be so,' Robert put in; 'but you are up against men who want the money you owe them. Try telling them that God wants you to carry on with their money, and see what they will say.'

'I tell you I'll get the solution. I might discover it any day: it's just a question of time and trying things. One of these samples,' he picked up a small square of rubber sheet from the dresser, 'will turn out to be the real thing.'

Nelson shook his head. 'You're hopeless! Why don't you take to your own business of merchant? There's nothing to be made from rubber.'

In exasperation Goodyear threw the piece of rubber from him and seated himself on a chair, his head in his hands. The three sat in silence for several minutes.

Then: 'What an unholy smell!' Robert exclaimed.

'It's that piece of rubber. It's fallen on the hot stove,' Nelson remarked and leant forward to remove it.

'Stop!' cried Charles, excitedly, and grasped his brother's arm. Eagerly he leant forward, his face near the smoking rubber. His brothers watched him in silence. 'I've got it at last! The rubber won't change any more. See, it's gone hard and the heat has no more effect on it.'

'We've heard that story many times before,' Nelson sighed.

But Charles Goodyear was right: the great discovery of 'vulcanization' had been made.

V

But that was only the beginning of further troubles, for Goodyear soon discovered that other specimens did not turn out like this first one. He had to discover by trial and error how much sulphur to put in the rubber, how long to heat it, and at what temperature.

He built a large brick furnace and into it put dozens of pairs of rubber shoes, but the fire completely destroyed them. He tried again and again and the same thing happened. He was penniless, begging for food, and visiting neighbouring factories to ask permission to use their furnaces for his experiments.

Then one of his sons died, and, soon afterwards, he received news that his father and his youngest brother and his wife and child had all died of the yellow fever in Florida. Charles himself was again sent to prison for debt. But still this delicate little man would not give in.

In 1841 the first successful rubberized cloth was manufactured, but Goodyear continued to experiment for three years more. Then he had his process patented, and just in time, for a dishonest

business man, Horace H. Day, had heard about vulcanization and was about to claim the invention as his own.

Goodyear then had a factory set up near his home town in Connecticut, and very soon dozens of other firms were making rubber goods of all kinds: goods which neither heat nor cold would affect. The inventor moved from factory to factory, teaching the process and carrying out further experiments. He discovered that, by the addition of much sulphur and other treatment, rubber could be made as hard as wood.

All this time Horace H. Day was doing his best to swindle Goodyear out of the money due to him from the patent, claiming that he was a cheat and that he himself had really discovered vulcanization. At last the dispute went to court and in this, the Great India Rubber Case, it was decided that Charles Goodyear was without doubt the real inventor.

But bad luck followed Goodyear to the end. In England Hancock was given the patent for rubber and, although Goodyear received high praise for his marvellous display at the Great Exhibition at the Crystal Palace in 1851, he earned no money for his invention in England.

Later he went to France to show his rubber articles at a great exhibition in Paris, but there also they would not allow his patent, and this poor, sick genius, hobbling on his crutches, was actually put in prison for debt.

He died in 1860 in New York, while on the way to the funeral of one of his daughters, leaving nothing and owing over $200,000.

So ends the sad story of Charles Goodyear, the man who gave us the rubber that means so much to us nowadays. Although a sick man all his life, he never gave in. Caring not at all for money, he devoted his life to serving mankind, and in return mankind cheated him in every way. Even to this day few people know anything about him.

THE BROTHERS WRIGHT

I

THE spanner tinkled to the ground and, with an exclamation of annoyance, the young man straightened himself, examining his grazed knuckles. Turning, he leant against the bench and looked across at his brother, who was working at a lathe at the other end of the workshop. After lighting a cigarette and wrapping a rag round his bleeding hand, he went and stood in the doorway, looking out into the street.

The lathe stopped, and the man who had been working it, a clean-shaven fellow of about thirty, looked towards his younger brother. 'What's the matter, Orville; hurt your hand?' he inquired.

'It's nothing. The spanner slipped and I grazed my knuckles.'

'You look annoyed, all the same.'

'It's these bicycles! Why we ever sold the newspaper business and started manufacturing bicycles, I cannot imagine.' He stepped outside and looked up at the board above the door. 'Wright Brothers. Bicycle Manufacturers', he read. 'There's about as much excitement in making and mending bicycles as there is in sweeping the streets of this town of Dayton.'

'Well, the idea was yours, my lad. You said there was money to be made in the business, and persuaded me to come in with you. And you were right! We have done pretty well and we both have good fat bank balances.'

'Don't you ever get bored, Wilbur? I prefer this mechanical work to sitting at a desk all day; but it gets monotonous putting these frames together and adjusting spokes and so on, day in, day out.'

Wilbur Wright did not answer, but bent to the lathe, while his younger brother, Orville, wandered across the room and, picking up a newspaper, seated himself on a bench and began to read idly.

'Did you ever think of making a flying machine, Wilbur?' he said at last.

Immediately the lathe stopped, and the other man turned to look at him. 'What's that you say?'

Orville repeated his question, adding: It says in the paper here: "Death of German Bird Man. Otto Lilienthal, who has devoted his life to the study of the flight of birds, has been killed when a flying machine, which he had made, dived to the ground ——"'

'You needn't read any more. I saw it myself this morning. And, strangely enough, I can't get the idea out of my mind.'

'What do you mean? To make a flying machine? Better than these bikes!'

And so it was that the attention of the energetic Wright brothers was directed to experiments in flying. They borrowed all the books they could find in the neighbourhood of their own town of Dayton, in the state of Ohio, U.S.A. Then, so engrossed did they become, that they wrote to the great library in Washington and borrowed from there.

II

Before tackling a difficult problem it is always as well to find out all one can about it, and this is what Orville and Wilbur Wright were now doing by reading about the earlier attempts to fly. Let us see how far man had got in the year 1896 in trying to imitate the birds.

From the earliest times men have envied the birds their ability to soar in the air, and there are many old stories of men trying to copy them. Perhaps the most famous of them is told by the ancient Greeks about a man called Daedalus, who made wings for himself and his son Icarus. They foolishly fastened the wings together with wax, so the legend says, which, when they flew too near the sun, melted; and you can imagine the result.

The first man to try to reason the matter out was the famous Italian painter and inventor, Leonardo da Vinci, who made wise suggestions and drawings for flying machines.

It was not until the seventeenth century, long after Leonardo's time, that men began to think seriously about flying. They discovered that there would be two ways of bringing it about:—the first, to make a flying machine lighter than air to float in the air, just as a boat floats in water; the second, to fly like birds. We shall see now how they managed with the first method, and talk about the second later.

In 1670 a priest called de Lana wrote a book showing how a lighter-than-air flying machine could be made. It was to be in the shape of a boat, and on the top of four poles, two on each side of it, were to be four huge balls of thin copper, from which all the air had been pumped. In the middle of the boat a tall mast would carry a sail, and there were to be oars as well. This queer machine would not have risen from the ground, even if de Lana had built it, for the balls would not have stood the pressure of the outside air when the air had been pumped from inside. But the reason he would not construct it was because he believed that God would not let such an invention work, as from it 'fire-works and fire-balls' could be dropped on ships and cities and castles.

Over a hundred years later two brothers called Montgolfier used an idea rather like de Lana's; but, instead of pumping all the air out of their 'balloon', as they called it, they filled it with hot air, which is lighter than ordinary air. They were paper manufacturers and they built a huge ball,

made of canvas and lined with paper, which was over thirty feet in diameter. The bottom of the balloon was open, and under the opening was fixed a furnace, from which rose the hot air to fill the balloon, while round the lower part was a gallery to carry the passengers. The king of France and a huge crowd of people watched as the fire was lit, and when the hot air had filled the balloon, it soared into the sky with two men on board.

Some years before this an English scientist called Cavendish had discovered the gas, hydrogen, which is very much lighter than air. Almost at the same time as the Montgolfier balloon took its first flight, another Frenchman, M. Charles, made another balloon, and filled it with hydrogen. A great crowd watched as it rose, although this was only an experiment and no one was in the basket. It floated out of sight, and at last landed miles away in a village, tearing itself on a tree as it fell.

The great monster flopped down into the street, heaving as the gas escaped, and the people ran in terror. At last they summoned sufficient courage to creep up to it and attack it with guns and pitch-forks.

Two years later Blanchard crossed the English Channel in a gas balloon, and after that people began to get used to seeing these monsters.

But the balloon was of little use for travelling, for it can only go where the wind blows it, so during the next hundred years experiments were made with airships, or 'dirigibles', as they are called, because

they can be steered. The most famous of them were made by the German, Count Zeppelin, and during the Great War of 1914-1918 his airships made fifty-three air-raids on England.

III

The Wright brothers did not concern themselves with balloons, but set out to discover the second kind of flying we mentioned—flying like the birds. Let us now see how much was known of this before Wilbur and Orville started their experiments.

In early times people thought that the only way to fly like birds was to make wings that could be flapped by men's arms, but a scientist called Borelli had written in the seventeenth century that man's muscles were not strong enough for this; and, of course, he was quite right.

The first really important writer and inventor on flying in a heavier-than-air machine was the English Sir George Cayley, who lived over a hundred years ago. After watching birds in flight, he agreed with Borelli about flapping wings. He made a glider—rather like those we can make by folding paper—and, launching it from the top of a hill, found it would fly quite a long way. If you make a paper glider and throw it, it will fly until the push you have given it has lost its strength. Sir George said that if an engine could be put into it, it would

keep on flying. This is exactly how an aeroplane works.

But the trouble in those days was that the only engine was a steam engine. Its boiler and furnace and coal, of course, would have made it far too heavy to fly. Some time later an inventor called Stringfellow made a large model aeroplane with a tiny steam engine to drive it, and this actually flew a few yards in a large room.

But the person who, through his books, taught the Wright brothers most, was the man whose death they had read about in the papers—Otto Lilienthal. From his childhood Otto had been interested in flight, and he used to spend hours watching the birds circling round his house in Germany. He wrote books on what he discovered, and set to work to make himself a glider of bent willow rods with cotton cloth stretched over them. Between the wings was a hole through which he put his head and shoulders, and, hanging by the arms, he floated, at first a few yards only and then for quite long distances.

Near his house a canal was being dug, and to build himself a hill fifty feet high he used the earth that the navvies had removed. From the top of this he launched himself into the wind and, after trying many different types of glider, he at last succeeded in flying so well that he determined to fit an engine into his machine. But before he could carry out this plan, his glider crashed and he was killed.

In 1896 an American, Professor Langley, after studying flying for many years, built a model with an engine, which flew successfully across a river.

It was about all these men and many others that Wilbur and Orville Wright read in the next few years. How near were these inventors to flying, and what was there left for the Wrights to do? We have seen that people had learnt to fly in balloons and airships: but airships are too big and clumsy to be safe in the air. Men had found that it was possible for 'heavier-than-air' machines to fly, if only they could be made in the correct way, and if only a light and powerful motor could be found to drive them.

IV

Wilbur and Orville now decided, having learned all they could from books, to see what they could do about making a flying-machine. They were in their workshop one day in the year 1898 talking about this.

'What we have to do,' Wilbur was saying, 'is to make a machine that will glide, and then find out how it behaves in the air and how we can control it. The mistake made by a lot of these fellows we have been reading about is, that they tried to plan on paper a complete flying-machine. Even if they had made one that would fly, the first time they took it up they would probably have been killed and the machine smashed.'

'You're quite right; we've got to learn to glide before we can expect to fly.'

'Look here,' Wilbur continued, 'if you want to ride a horse you don't spend a couple of hours sitting on a fence watching his antics, and then work out on paper how to overcome them. You get into the saddle and try to manage him.'

'How far have we got, then? We have plans drawn out here for a machine that would fly at eighteen miles per hour, if we could only get a motor for it.'

'The thing to do is to get it built. Never mind the motor. If we can find a place where there is a steady wind of eighteen miles per hour, the thing will fly like a kite at the end of a rope.'

'I see your idea,' Orville nodded; 'then, when it is in the air we can see how it behaves. We could fit strings to the controls so as to work them from the ground.'

'That's right. But the great trouble is to keep the machine balanced. While the wings are level, the thing is simple; but when one goes up and the other down, you fall.'

'Lilienthal used to use his body to balance his gliders; but of course that would be no good in a big machine. My plan of bending the wing-tips is the solution, I'm certain.'

'I believe it is,' Wilbur admitted. 'However, we'll know when we get the machine into the air. How do you propose to find a suitable place for flying—I mean with the right kinds of winds?'

'That's easy. We can get in touch with the weather people at Washington; they'll tell us. Here's the paper-boy. Let's see what's going on in the world.' Orville went to the door and took the newspaper and ran his eyes over the columns. He had reached the back page when he drew in his breath sharply, and whistled.

'What's up?' his brother asked, looking over his shoulder.

'See here!' Orville pointed, and read: '"The War Department has made a grant of $50,000 to Prof. Samuel Pierpoint Langley of the Smithsonian Institution, Washington, for the construction of a flying-machine that will carry a man. Prof. Langley has carried out experiments over a number of years with model flying-machines, and, two years ago, a model of his, driven by a small steam engine, was flown across the Potomac River." We'll certainly have to hurry if we want to be first.'

'It will be difficult to beat him, seeing that he has the best laboratories and workshops in the country to use.'

'But he hasn't the knowledge we have, judging by what he has written about flying.'

V

Two years later, in 1900, the Wrights arrived at the small village of Kittyhawk, which is on the coast of North Carolina. They had written to

Washington, and the weather bureau there had told them of this place, which was well suited to their purpose, for there were miles and miles of flat sand along the shore, and not far from where they pitched their tent there were the low Kill Devil sand-hills. The local post-master had told them it was the very place for boys who wanted to play with flying-machines.

In their tent they put the glider together and then tried to fly it at the end of a rope. But this did not work at all well, so off they went to the Kill Devil hills and started gliding in earnest.

Their machine was a biplane. There were two oblong wings, one above the other, and immediately behind was an upright, square rudder to make the machine turn to right or left, while at the front was a flat, level plane on a level with the lower wing. This plane could be tilted up and down by the hands of the pilot, who lay flat on the lower wing.

All the summer they experimented and at last managed to glide quite a long way. In the autumn they went home and spent the winter building an improved glider.

Next summer they returned to Kittyhawk and again spent their time gliding; but they were not satisfied with the results; so when they returned to their workshop, they built a wind-tunnel—a large tube, through which air could be driven by a fan—in which they could carry out careful experiments.

When they went to Kittyhawk again in 1902 they found that their new glider worked very well indeed, so they decided to build a bigger one and fit an engine to it. By this time the petrol motor, which is much lighter than a steam engine can be, had been invented, so they set to work to design and construct one in their workshop. When it was finished, it had four cylinders, like a motor-car engine, and was of twelve horse-power.

This proved to be a very long job, and it was not until the end of September 1903 that they again arrived at Kittyhawk and began to put their machine together. All sorts of mishaps occurred—the propeller shaft became twisted, the weather was bad, and they lost one of their workmen. On October 8th they had gone from their tent into the little town of Kittyhawk.

'Let's see if there is any news of Langley's machine,' said Orville, buying a paper and pausing to glance through the columns. 'Look here, Wilbur!' he exclaimed a moment later: '"Yesterday Prof. Langley attempted to launch his big flying-machine from a house-boat on the Potomac River. The launching tackle fouled, and the machine dived into the river. Prof. Langley says he is confident his machine will take to the air and intends to have it repaired and to try again as soon as possible."'

'Gee! We'll have to hurry. Come on, let's get back to the "Flier."'

VI

While work was going on feverishly on the sands at Kittyhawk, Prof. Langley completed the repairs on the 'Aerodrome', as he called his machine.

On December 8th a great crowd gathered on the banks of the Potomac River to gaze curiously at the large house-boat on the top of which, on a launching-way, rested the huge birdlike machine. Prof. Langley watched eagerly as the engines were started. Then he gave the word, and the machine began to move forward. It was on the point of leaving the boat, when something became entangled in the tail. The great bird reared up in the air, then, with a mighty splash, landed in the river a few feet from the house-boat. After the unfortunate pilot had been rescued, the War Department officials told the professor that they were not satisfied with his machine and could give him no more money to carry on his experiments.

Nine days later an important event occurred at Kittyhawk.

VII

December 17th, 1903, was a cold, windy day. On the sands at Kittyhawk a small group of men stood, five being spectators, and the other two Orville and Wilbur Wright. In the sand was set a long, metal-covered, wooden rail, eight inches high. At one end of this rested the 'Flier', very similar in

shape to the Wrights' first glider, but bigger, and fitted with the motor-engine, connected to two propellers behind the wings. The time was 10.30 in the morning.

All was ready and the two brothers looked at each other inquiringly. Orville produced a coin and spun it. Wilbur called wrong and, with a grin, the other climbed into the machine, placing himself flat on the lower plane. The engine was started and, while the spectators watched breathlessly and Wilbur ran along side, the 'Flier' began to move along the rail. It gathered speed and, after travelling forty feet along the rail, rose gradually into the air to the height of eight or ten feet. For twelve seconds the machine travelled at the speed of ten miles an hour and then landed on the sand.

Three more flights were made that morning, getting longer as the brothers became more skilful with the controls. The fourth lasted nearly a minute and covered 852 feet.

You can imagine the joy of the brothers. They had been the first men to fly—as distinct from gliding—in a 'heavier-than-air' machine. Satisfied that their machine would fly, they returned home and, during the winter, made a bigger and better one. When it was completed they invited the newspaper men to come and see it fly; but the machine refused to behave itself that day, and the reporters went away without very much faith in the Wright brothers.

People were too accustomed to hearing of men

trying in vain to fly, to take much notice of the claims of the two inventors. One day a newspaper reporter lay hidden behind a hedge watching the two brothers. When the aeroplane rose into the air and flew about, he was astonished and dashed off to the post office to send the story to his paper. But the editor would not believe it and the reporter got into trouble for sending such nonsense.

VIII

The Wrights now had their machine patented, and offered to sell it to the British and American Governments; but neither was interested, so Wilbur went to France with a machine to prove to the people of Europe that it really would fly. By this time inventors in France had managed to make aeroplanes that would fly; but, when Wilbur Wright arrived there in 1908, he found that his machine performed in the air much better than the French ones. He amazed everyone by flying ninety miles in two hours and twenty minutes.

In the next few years the aeroplane rapidly improved, and in 1909 Bleriot flew across the English Channel. In 1919 the Atlantic was flown, and in 1924 two United States Army planes flew round the world.

Wilbur Wright died in 1912, but his brother, Orville, still lives (1943) and is honoured as a very great man.

That is the story of the Wright brothers, the inventors of the first aeroplane. We must admire them for their courage and perseverance, for they made this wonderful discovery by their own efforts in their bicycle workshop, without being trained as scientists, and without the intricate appliances of a laboratory.

THOMAS ALVA EDISON

I

'THAT youngster of yours has grown since I saw him last, Sam,' said Captain Alva Bradley, as he filled his long clay pipe. The two men sat on the veranda of Samuel Edison's little house in the village of Milan, in Ohio, near the great American Lake Huron.

Sam watched his youngest son, a tousle-headed lad of about six, who had been sitting at the other end of the porch looking at a book, get to his feet and run off in the direction of the street. Then he replied to his companion's remark.

'Yes, Al, he's grown in the last year. And he's getting a smart lad. Talk about asking questions! It's always 'why? why? why?' His mother never tires of answering him; but I soon give up.'

'I've heard about him on the lake,' the other said. 'I was talking to a barge man the other week. I told him I knew Milan, and he said: "Then you'll know that youngster, Al Edison?" "Know him!" I said; "Isn't he named after me? What's he been doing?" "He was trying to walk the logs on the river like the lumber jacks, and roaring their songs at the top of his voice," said the barge

man. " Suddenly he took a header into the river and I just managed to get a boat-hook and pull him out." '

Sam Edison laughed. 'I never saw his equal for inquiring about things.' He was proud of young Al and pleased to get the chance to tell of his doings. 'I expect he's gone up to the farm to bother them with his questions.

'The other week he went to the grain store and climbed to the top to watch the wheat pouring in. He leant over too far and fell in. If one of the men hadn't seen him and pulled him out he'd have been killed.'

The captain laughed and re-lit his pipe.

'Then there was the time when I found him up at the farm,' went on Sam Edison. 'He was coming out of the barn. And you should have seen the seat of his pants ! I asked him what he'd been doin'. " Sittin' on eggs to hatch out chickens," he said. Then he asked why he shouldn't be able to do it, since the goose could ! '

'I bet you couldn't answer that one, Sam ! ' the captain chuckled.

'Then there was the time he wanted to know how a bees' nest back in the hedge there worked. He looked in and nothing happened, so he began prodding with a stick. Just then a goat came and butted him into that bees' nest, and the bees didn't like it a bit. You should have seen his face and hands when he came running home ! '

'That lad will go a long way,' the other

prophesied. 'It's good for him to find out things, as long as he does no harm.'

'He never does any harm—except to himself and his clothes.' As he finished speaking, Sam Edison wrinkled up his nose and sniffed. 'Do you smell anything? Like burning?' he inquired, getting to his feet.

'There's smoke over there,' the captain said, and the two men went into the street.

'Seems to come from the direction of the farm. Why, there's young Al, running as if there was a mad bull after him.'

And so he was: but the 'mad bull' was a very angry farmer.

'Set my barn on fire, would you?' he was roaring.

Sam Edison went into the house and then came out again with a very switchy cane. 'Why did you do it?' he asked in a terrible voice.

'I wanted to see what would happen,' answered his son.

'Come with me, and I'll show you.' Sam Edison took him by the hand and led him down the street.

And that is how the world's greatest inventor was publicly spanked at the age of six in the market place of Milan, Ohio, in the year 1853.

II

The next year the Edison family moved to a town called Port Huron. Their new house was a large

III

If you had travelled any day during the next four years on the train that ran between Port Huron and the city of Detroit, a distance of seventy miles, you would have been offered papers, fruit, and candy by an untidy-looking, tousel-headed boy. That boy was Thomas Alva Edison.

If you had followed him to the luggage van at the back of the train, you would have found there piles of books and a laboratory. Several times during the journey Edison would walk along the train selling his wares to the travellers; then he would hurry back to the luggage van and either read science books or carry out experiments.

When the train drew into the station at Detroit, Al would at once dash off to the Public Library, where he would study during the middle of the day, and then dash back to continue his duties on the train during its return journey. To save the time it would have taken him to walk home from the station, he used to jump out of the moving train a quarter of a mile outside Port Hutton, on to a heap of sand he had placed beside the track. There, Michael Oates was always awaiting him with the pony and trap.

Very soon Edison had boys working for him selling fruit, vegetables, and papers in Detroit and the other stations; and he made a great deal of money in this way.

One day when he was in Detroit, he saw a small,

second-hand, printing machine. It was very cheap, so he bought it and installed it in his luggage van. Before long he was issuing his own newspaper, *The Weekly Herald*. He wrote most of the articles himself, and the telegraph operators, who were his friends, collected bits of local news for him. He sold four hundred copies a month.

But these prosperous days came to a sudden end when Edison was fifteen. He was working busily at his printing-press in the luggage van one day, while one of his news-boys was selling papers in the coaches, when suddenly the train jolted violently, and a stick of phosphorus was thrown on to the floor and burst into violent flames. Edison tried to put the fire out, but could not, and it began to spread to all parts of the van. At last the conductor arrived with pails of water and managed to subdue the flames.

The danger past, he turned to the young inventor, boxed his ears soundly and told him exactly what he thought of him. When the train reached the station, he opened the luggage van door and threw printing press, chemicals, papers—everything—on to the platform. And that was the end of the first laboratory and printing-press on wheels.

IV

One summer morning shortly after this Al Edison was standing talking to one of his telegraphist friends, a Mr Mackenzie, on a station platform.

Shunting was going on, and the roar of a truck travelling quickly along the line caused Edison to turn. To his horror he saw Mackenzie's little boy wander on to the line in front of the fast-moving truck. Without a moment's hesitation, Al dropped his papers and sprang after the child. The side of the truck grazed Al's ear as it roared by, and the two boys fell on their faces on the gravel at the other side of the track.

Mackenzie wondered how he could repay the boy for saving the life of his son, and next day, when Al came to the station, he said he would teach him to use the telegraph and try to get him a job on the railway. For the next month Edison devoted all his attention to mastering the Morse Code and the use of the telegraph key. Then he gave up candy and papers and became a telegraphist.

For the next five years Thomas Edison worked as a telegraph operator in many parts of the United States, usually doing night work, so that he could carry on with his experiments during the day. Many stories are told about him during this period. One evening he came into the telegraph office carrying a box. 'I don't suppose it's any good,' he muttered and put it on a shelf over the empty stove. Then he forgot all about it. The next time the stove was lit, there was a terrific explosion. Edison had tried to make gun-cotton—and succeeded!

Then there was the time when he electrocuted the cockroaches which used to climb on to the telegraph office table and eat the food. He placed

two long strips of tin-foil, nearly touching, round the edge of the table and connected them to a battery. As soon as the cockroaches tried to cross these, they dropped down dead.

At last some of his friends persuaded him to go to New York, and there he went, without a cent in his pocket. He begged a cup of tea for breakfast and then went in search of a telegraphist friend, who lent him a dollar. Someone gave him permission to sleep in the store-room of a works, where there was a lot of intricate machinery for sending out the latest news to all the offices round about.

Edison was sitting there wondering what to do next, for he had spent the last of his dollar, when he suddenly realized that something had gone wrong in the works. The machines had stopped, and none of the workmen could find out why. Very soon Edison had discovered the trouble and the machines were at work again. The head of the business was so delighted that he made Edison his manager, and before long the latter had invented a much better news-machine, which he patented and sold for a very large sum of money.

Thomas Edison now decided to spend all his time inventing, so he set up a laboratory in New Jersey, and there employed two hundred and fifty men. In the next six years he perfected one hundred and twenty-two inventions, mostly to do with the telegraph. He made it possible to send many

messages along the same wire at the same time, so saving the expense of laying a large number of lines; he also made a machine which would automatically take down messages and another which would send them, so that three thousand words a minute could be telegraphed. As well as this he helped in the invention of the typewriter.

In 1876, when he was twenty-nine years of age, Edison moved to his famous laboratory at Menlo Park, a village twenty-five miles from New York. One of his first tasks there had to do with the telephone, which Alexander G. Bell had invented some time before. Bell's telephone sent such weak messages that they could not be heard at all over a long distance. Edison set to work and so improved the instrument that the voice could be heard as far as the wire stretched.

V

One day in 1877 Thomas Edison was working in his laboratory with a telephone receiver. When he spoke into it, the round, thin metal plate inside trembled. The inventor paused for a moment in his work to think, and during the next few days he spent a good deal of time considering, for an extraordinary idea had come to him. That metal disc had given off the same sound waves as his own voice; he knew that, for that was how the telephone worked. His idea was this: if he could make that

metal disc, or some other thing like it, tremble in exactly the same way when he was *not* speaking, he would hear his voice come from it.

He spent the night drawing and thinking, and, on the next day, sent for one of his best workmen, John Kruesi.

'Make a model of that drawing, John,' he ordered, handing him the paper.

Kruesi looked at it curiously. 'Whatever is it, Mr Edison?' he asked.

'It's a machine that will talk. Get it ready, and you will see.'

The workman looked at him as if he were joking. Then he went and started on the job.

Two days later the simple machine was ready. It was a metal cylinder with a spiral groove cut on it and a handle to turn it. It was mounted on a wooden base. Along the side was a metal bar on which moved a tube with a round piece of parchment in it. To the middle of the parchment was fastened a needle.

All the scientists and workmen gathered round to see what the inventor would do with this strange machine.

'It talks,' Edison declared; and they all laughed. 'I'm serious; just wait and you will hear.'

He took a sheet of tin-foil and wrapped it carefully round the cylinder; then he moved the tube along the bar until the needle rested on the tin-foil, pressing it into the spiral groove. Turning the handle, he made the cylinder revolve, and at

the same time stooped and, with his lips close to the end of the tube, which held the parchment, shouted :

'Mary had a little lamb ;
Its fleece was white as snow ;
And everywhere that Mary went
The lamb was sure to go.'

This, of course, made the parchment tremble, and the needle drew a plan of the trembling in the form of a line composed of tiny waves going round and round the drum. Then Edison moved the needle back to the starting place and again turned the handle.

It worked ! His voice came out of the tube. He had invented the talking machine—the 'phonograph'. We now call it the gramophone.

Next day Edison walked into the office of the editor of one of the biggest New York newspapers with a package under his arm. He took off the paper and placed the new machine on the table in front of the newspaper man.

'What have you got there, Mr Edison ?' the latter asked.

But Edison just grinned and pushed the machine nearer him. The editor took hold of the handle and turned it.

'Good-morning ! How do you like the new phonograph ?' came from the machine. The editor nearly fell off his chair with surprise, and Edison roared with laughter.

Soon the news was all over America. Edison had invented a machine that talked. Impossible ! How could a *machine* talk ? Crowds flocked to Menlo Park to hear for themselves, and soon the inventor was asked to go to Washington to show his machine to the President of the United States.

Before many years had passed, the phonograph was to be found in homes all over the country. Later on, Edison invented disc records, like those we have to-day.

Soon after this, Edison, having put in months of hard work, made the first successful electric lamp. The great difficulty here was to find a metal wire that would stand the tremendous heat when the electric current made it white hot, and yet not burn away. He tried everything else he could think of. Then he discovered that, if he fixed inside the glass bulb a piece of ordinary cotton thread which had been roasted until it was carbon, and then pumped out all the air, his object was gained. The lamp burned for forty-five hours and he and his helpers watched it all that time ! This put Edison on the right track and at last, after sending searchers all over the world, he found that thin threads of bamboo changed into carbon made the best filaments for lamps.

Thus houses and streets could be lit with electric light.

VI

It would take hundreds of pages to tell of all Edison's many inventions. We have space to tell of only one more: and this, like the talking-machine, seems very simple.

It occurred to the great inventor that if a camera could take photographs very quickly, one after another, of, say, a man moving, and if the film of all these pictures was in a continuous length, it could be passed rapidly through a magic lantern, and would show on a screen a picture of the man moving. So Edison set to work to make a camera and a suitable type of magic lantern, or projector, as it is called. Thus we owe the cinema to Thomas Alva Edison as well. In 1912 he combined the phonograph and the cinematograph to make the first talking-picture.

No man has ever worked harder than Edison. Often he was in his laboratory for twenty hours a day, and sometimes he worked there for days on end, only lying down on a bench now and then to snatch a short sleep. He was so enthusiastic about his work that his helpers—'the boys', he always called them—were ready to work just as hard as he.

He died in 1931 at the age of eighty-four, and, until a few months before his death, worked as hard as ever. That is the story of how a newspaper-boy who refused to go to school became one of the most famous men in the world.

GUGLIELMO MARCONI

I

In the summer of 1894 two men sat in an hotel in the Alps. They had had a long, tiring day in the mountains, and the elder dozed in his chair. The other, a young fellow of twenty, of medium height, with blue eyes and fair hair, was reading a scientific paper, which he had found among the magazines and newspapers provided by the hotel for the entertainment of its guests.

The elder man at last stirred himself and looked at his watch. 'I'll go up to bed now, Guglielmo. It's after ten, and we want to make an early start in the morning,' he said, rising.

But Guglielmo Marconi appeared not to hear him.

'What are you reading?' his half-brother, Luigi, inquired, looking over his shoulder. 'Electricity again! What a man!'

The younger Marconi looked up with a smile. 'I'll follow you later. I must finish this article,' he said, and returned to his reading.

The article that Guglielmo found so interesting was about an experiment, carried out by a scientist called Heinrich Hertz, who had died the year before. Hertz had discovered that, if he made an electric spark jump across a gap between pieces

of metal in an instrument at one end of his laboratory, another spark would jump between two other pieces of metal, placed very close together, in an instrument at the other end of the room; although there was no wire connecting the two instruments.

That certainly looks like magic. But scientists can explain it. They believe that everywhere—in the air, beyond the air, among the sun, moon, and stars, in the earth, in everything—there is what they call 'ether'. Even the scientists do not know what ether is. Light consists of very small wave-movements in this ether—like the movement of ripples in a pond when a stone is thrown into it, but far, far smaller.

Hertz said that his electric spark caused waves in the ether, and that these travelled to the other instrument and caused it to spark also, and that, like waves of light, they travelled at 186,000 miles a second. That is over seven times round the world in a second!

Now these ideas were not quite new to the young Marconi, for he had always been fascinated by electricity and had read many books on science. In fact science was his hobby, and when he was not fishing or riding he was almost certain to be in the laboratory, which he made for himself on the third floor of his home near Bologna, in Italy.

It was very late before Guglielmo followed his brother up to bed, for an extraordinary idea had come to him. If a spark could cause ether waves to travel to another machine across a room and

make that machine spark, why could not a bigger spark make waves travel a longer distance and cause another spark, say, a mile away? And, by using long and short sparks, why could not this be used to send messages by Morse Code? Indeed, why should not messages be sent this way over great distances, using the ether instead of wires?

The elder man found his young brother poor company during the rest of that holiday, for Guglielmo was so interested in his idea that he could not take his thoughts off it.

II

At last they arrived home at their father's mansion outside Bologna, and young Marconi hurried to his laboratory to start his experiments. Assisted by his brother Alfonso, who, although nine years his senior, was not ashamed to work under this brilliant young scientist, he struggled for months testing his idea. At last, to their joy, they got the instrument at the other end of the room to give its answering spark.

Marconi now decided to show his father that there really was something in this idea of his, for Signor Marconi, who had made a large fortune in business, had not a great deal of faith in his youngest son's science.

At last the apparatus was ready, and Guglielmo invited his father and mother to come to the laboratory.

Signor Marconi entered, his good-humoured face beaming. 'What is this new toy you have made, my boy?' he asked.

'Listen!' the young inventor said, and he pressed a switch.

Faintly, in the lower part of the big house, an electric bell rang.

'Well?' his father inquired.

'There are no wires running to that bell. Don't you see what it means, Father? Messages can be sent through space without wires to carry them.'

But Signor Marconi was not convinced. 'Let me take one of your machines down to the lawn. Then, if you can send me a signal, I'll believe you,' he said.

Marconi took him at his word. A little later he was back in the lab., his hand on the morse key. Through the window he could see his father at the receiver. The young man's heart thumped as he tapped ••• the test signal, S, which telegraphists use. He could tell by the expression on his father's face that the message had got through.

That evening Signora Marconi talked to her husband, and on the following day Guglielmo was overjoyed to receive from his father 5,000 lire—about £250—to help with his experiments.

The hard work continued for months. Then one day Alfonso stood by a wireless receiver over a mile away. He was within sight of the laboratory window, and he held in his hand a flag. Guglielmo pressed the morse key, the sparks crackled on the

instrument by his side—and Alfonso waved the flag. The message had gone over!

Then Alfonso moved the receiver so that a hill was between it and the laboratory. This time he had a gun with him. Again Marconi sent his three dots. At once he heard the report of the gun. So these wonderful waves could travel through or over hills!

III

The young inventor now decided to offer his marvellous invention to the Italian government. But it seemed too marvellous to be true, and the high officials refused to buy it. So Marconi started for England, hoping to fare better there. His mother was Irish, and he spoke English as well as his native Italian.

Marconi's fame had reached England before him, and many well-known scientists were eager to question him. One of these was Sir William Preece, Engineer-in-Chief of the Post Office, who was an expert in all matters to do with telegraphy. Many people, of course, scoffed at the idea of sending messages without wires—just as people had laughed, years earlier, when Bell talked about the telephone—but the scientists realized that this modest young Italian had found something that they had all missed. Sir William Preece allowed Marconi to use his own laboratory, and there, and at some seaside places,

the experiments continued; as each month passed the wireless messages travelling farther and farther.

After a patent had been obtained in 1896 people had enough confidence in the new invention to risk their money. £100,000 was collected to form a company to instal wireless in lighthouses and lightships. This pleased Marconi a great deal, for he had always believed that his invention would do much to help sailors.

Then Sir William gave Marconi a big chance. At his invitation a large number of Army and Navy Chiefs and important Post Office officials gathered on Salisbury Plain to see for themselves what magic this young Italian could perform.

Marconi worked nervously to get his queer, crude, instruments into adjustment. The receiver was two miles from the sender, and to all present it seemed impossible that the morse message could travel across that long distance without wires.

The young inventor, his heart fluttering in case anything should go wrong, put his hand on the key. The sparks crackled; but he dared not look for the signal which would tell him that his message had carried. But he soon knew that all was well, for those important persons shook his hand and congratulated him; and he returned to London very happy.

Next year Marconi performed a feat which made everyone talk of him and his wireless. A big yacht

race was to be held off the coast of Ireland. The inventor decided to hire a steamer and send a running commentary of the race to Dublin by wireless.

As the beautiful white yachts flew through the water, he followed them, and his sparks crackled, sending the dots and dashes across the miles of water to Dublin, where the newspaper men typed them out and pinned them to notice boards for all to see. This was indeed a wonder to the people, for the result of the race was known on shore, while the yachts were still out of sight over the horizon.

There was no longer any doubt about wireless. Everyone talked about the brilliant young Italian and his invention. All the newspapers were full of prophesies. Some people even suggested that it might some day be possible to flash a message across the Atlantic Ocean! In the same year messages were sent from the royal yacht, where Prince Henry was ill, to Queen Victoria; and Marconi joined England to France by wireless.

'But,' people objected, 'if messages are sent through the air, won't everyone who has a receiving set be able to listen to them? And suppose a lot of people are sending messages at the same time? Won't they all be jumbled together?' But Marconi soon had an answer for them. He invented 'tuning'—that is, sending and receiving messages on different wave-lengths.

IV

Just outside the town of St. John's, the capital of Newfoundland, overlooking the harbour, stands a high, rocky hill. On the top of this is a disused barracks, where soldiers used to be stationed, and an old signal tower. On a Monday in December 1901, three men climbed this hill, carrying with them strange-looking instruments, which they set up in the yard of the barracks and in the tower.

On the following day they blew up a large, round balloon with gas and let it rise into the air. Attached to it was a long piece of copper wire. Up and up it went, while the three men watched anxiously. Then, suddenly, it started to toss about. They felt the copper wire go slack, and the balloon began to drift out to sea. Disgusted, they watched it disappear. Then one of the men turned to the youngest of the three.

'There goes our aerial, Mr Marconi!' he said.

'What now?'

'We'll have to try a kite, Kemp. You and Paget get it unpacked.'

It was Thursday before everything was prepared. And a bitter, stormy Thursday it was! Inside the tower sat Marconi, his queer wireless set before him, and a telephone receiver standing ready.

Kemp entered. 'The kite's flying well—though it's a wonder it does in this weather!'

'All right; go and keep an eye on it. But stay within call.'

Marconi looked at his watch. It was nearly time. In a few moments, nearly two thousand miles across the Atlantic Ocean, in Cornwall, England, someone would begin pressing down a lever ••• ••• ••• S S S. Tremendous sparks would crash with a noise like a machine-gun. But could they carry a message over those two thousand miles of ocean with nothing between but the ether and stormy water and roaring winds? Even to Marconi, who knew that they should, it seemed impossible now.

Again he looked at his watch. It was time to begin! He put the receiver to his ear and began to work with his instrument, searching for the wave-length. For half an hour he tried, all the time wondering, doubting. Then his fingers grew still. What was that? Very faintly, through the crackling in the receiver ••• ••• •••

'Kemp!' he called. 'Come here!'

His assistant ran into the room.

'Can you hear anything, Kemp?'

Kemp took the receiver and put it to his ear. In a moment a smile of triumph crossed his face.

Yes, there was no doubt about it; a message had come across nearly two thousand miles of ocean!

Soon the papers were full of the news. But people would not believe. 'The young Italian has imagined it,' they said.

So Marconi fastened to his receiver an automatic telegraph machine, which would write down the dots and dashes on a piece of paper tape. Soon

after, he crossed from Europe to America on the liner *Philadelphia*, and received messages each day during the voyage. The captain of the ship watched them come in and signed his name on the tape. Now no one could doubt that messages could really be sent by wireless across the ocean.

Five years later news began to be flashed regularly across the Atlantic.

But still this was not the wireless we know, for all messages had to be sent in dots and dashes. All this time other scientists were working on wireless, adding improvements, and it was not very long before people were astonished to read in the newspapers that not only morse, but actually the human voice could be heard over the air.

V

The year 1909 was, perhaps, the happiest in Marconi's life. This is why :

On January 26th of that year the luxury White Star liner *Republic* steamed blindly through a thick fog. She had just left America and was on her way to the Mediterranean with 461 people on board.

' Sparks ' Jack Binns was dozing in the wireless cabin. He was too used to the sea to be disturbed by the hoot, hoot, of the fog horn. But suddenly he realized that something was wrong. The ship's engines had stopped. He sprang out of his bunk and was at once flung to the floor by a terrific,

jarring crash. He struggled to his feet to find that the cabin was in ruins; where one of the walls had been, he could see out into the fog.

His first thought was for his wireless. The lights had gone out, and he switched on the emergency batteries. To his joy the set worked. - - - - - - - - - - - - he signalled. (That is CQD, the clumsy old distress signal; for · · · - - - · · · , which is SOS, had not yet come into general use.)

To his joy an American station answered.

'We are shipwrecked. Stand by for captain's message,' Jack signalled.

'All right, old man, where are you?' came the reply.

Binns rushed to the captain, who gave him this message: '*Republic* rammed by unknown steamer, twenty-six miles south-west of *Nantucket* Lightship. Badly in need of immediate assistance, but no danger to life.'

Meanwhile the captain had collected the crew and passengers on deck and was talking to them calmly. There was no danger, he said, if they did not panic.

On shore Jack Urwin, who had picked up the call, was tapping out messages to other ships, telling them to go to the rescue. Two liners—the *Baltic* and *La Touraine*—heard, and at once altered course.

'Sparks' Binns sat for hours by his set in the bitter cold, keeping in touch with these vessels; but the fog was so dense that it was almost impossible to find the sinking ship. The *Florida*, the ship which had rammed the *Republic*, was less badly damaged,

so it was decided to transfer the passengers to her. This was done without accident.

'How are you getting on?' signalled *La Touraine*.

'I am on the job. Ship sinking. Will stick to the end,' Binns answered.

At last the rescuing ships found the *Republic*, and all the passengers were taken to safety. The *Florida* was towed into port, and the *Republic* sank beneath the waves. Of course Jack Binns became a hero.

And so Guglielmo Marconi had saved over 400 lives. At once he set to work to find a way of discovering from what direction wireless messages had been sent, so that there would never again be any difficulty in finding a wrecked ship in the fog.

Three years later the wonder ship *Titanic* struck an iceberg and sank, and 1,517 people died: but 712 were saved through her wireless.

VI

The Italian boy, by this time a man of forty, was now one of the most famous and best loved men in the world. Honours had been given to him by all countries. The king of Italy had made him a marquis, King George V had made him a knight. He was very rich, and everywhere he went people asked him to give lectures. Newspaper reporters followed him about and he was invited to banquets,

where the greatest scientists made flattering speeches about him.

But he was never proud or stuck-up, but always shy and modest. When people were going to meet him for the first time, they expected that he would be untidy, in old clothes, and with long hair, like so many inventors. But what a surprise they got to find him always neat and well-dressed, 'just like a business man'!

When the Great War came in 1914, all the nations worked hard to improve wireless, and Marconi turned all his efforts to help his country, Italy.

When there was peace again in 1918, wireless was almost as far developed as it is to-day. Ten years later radio sets were in many houses, and people were beginning to talk of the Scottish inventor, Dr Baird, who said that soon it would be possible to see, as well as hear, by wireless. Of course Marconi was interested in television, too, as he sailed the seas in his beautiful, white steam yacht '*Elettra*', which was fitted out as a floating laboratory.

And so this famous man continued to experiment and improve the wireless he had invented, until he died in 1937. Then all the world was sad. But Guglielmo Marconi, who loved peace, who worked to make life safe for the sailors, who gave the world wireless so that all the nations could know and understand each other, would have been sad too, if he had lived three years longer to see the Italy he loved again plunged into war.